CLAIMS

1. A metal-to-metal antifuse disposed between two metal interconnect layers in an integrated circuit and comprising:

a tungsten plug disposed in a via in an insulating layer, said tungsten plug disposed above and in electrical contact with a lower metal interconnect layer;

an antifuse layer disposed above an upper surface of said tungsten plug, said antifuse layer comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer; and

a layer of a barrier metal disposed over said antifuse layer forming an upper electrode, said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride.

2. The metal-to-metal antifuse of Claim 1, wherein said layer of amorphous carbon is doped with at least one of hydrogen, fluorine, and hydrogen and fluorine.

3. The metal-to-metal antifuse of Claim 1, further comprising a second insulating layer disposed over and in physical contact with said layer of barrier metal, said antifuse layer, and said insulating layer.

4. The metal-to-metal antifuse of Claim 1, further comprising a spacer disposed in physical contact with said antifuse layer.

5. The metal-to-metal antifuse of Claim 1, wherein said antifuse layer is about 10 nm to about 80 nm in thickness.

6. The metal-to-metal antifuse of Claim 1, wherein said barrier metal layer is about 25 nm to about 200 nm in thickness.

7. The metal-to-metal antifuse of Claim 1, wherein said lower adhesion-promoting layer comprises amorphous silicon carbide, said middle layer comprises amorphous carbon, and said lower adhesion-promoting layer comprises amorphous silicon carbide.

8. The metal-to-metal antifuse of Claim 1, wherein said lower adhesion-promoting layer comprises amorphous silicon nitride, said middle layer comprises amorphous carbon, and said lower adhesion-promoting layer comprises amorphous silicon nitride.

9. The metal-to-metal antifuse of Claim 1, further comprising an oxide layer disposed on said barrier metal layer.

10. The metal-to-metal antifuse of Claim 1, further comprising a tungsten layer disposed on said barrier metal layer.

11. A metal-to-metal antifuse disposed between two metal interconnect layers in an integrated circuit comprising:

a tungsten plug disposed in a via in an insulating layer disposed above and in electrical contact with a lower metal interconnect layer;

a first layer of a barrier metal disposed above and in electrical contact with said tungsten plug forming a first electrode, said first layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

an antifuse layer disposed above an upper surface of said tungsten plug, said antifuse layer comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer;

a second layer of a barrier metal disposed over said antifuse layer forming a second electrode, said second layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride; and

a second insulating layer disposed over said first insulating layer, said antifuse layer, said first layer of said barrier metal, and said second layer of said barrier metal.

12. The metal-to-metal antifuse of Claim 11, wherein said layer of amorphous carbon is doped with at least one of hydrogen, fluorine, and hydrogen and fluorine.

13. The metal-to-metal antifuse of Claim 11, further comprising a spacer disposed in physical contact with said antifuse layer, said first layer of said barrier metal, and said second layer of said barrier metal.

14. The metal-to-metal antifuse of Claim 11, wherein said antifuse layer is about 10 nm to about 80 nm in thickness.

15. The metal-to-metal antifuse of Claim 11, wherein said first layer of said barrier metal layer and said second layer of said barrier metal layer are about 25 nm to about 200 nm in thickness.

16. The metal-to-metal antifuse of Claim 11, wherein said lower adhesion-promoting layer comprises amorphous silicon carbide, said middle layer comprises amorphous carbon, and said lower adhesion-promoting layer comprises amorphous silicon carbide.

17. The metal-to-metal antifuse of Claim 11, wherein said lower adhesion-promoting layer comprises amorphous silicon nitride, said middle layer

comprises amorphous carbon, and said lower adhesion-promoting layer comprises amorphous silicon nitride.

18. The metal-to-metal antifuse of Claim 11, further comprising an oxide layer disposed on said second layer of said barrier metal layer.

19. The metal-to-metal antifuse of Claim 11, further comprising a tungsten layer disposed on said second layer of said barrier metal layer.

20. A metal-to-metal antifuse comprising:

a first layer of a barrier metal disposed on a surface, said first layer of said barrier metal forming a first electrode, said first layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

an antifuse layer disposed on said first layer of said barrier metal comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer; and

a second layer of a barrier metal disposed over said antifuse layer forming a second electrode, said second layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride.

21. The metal-to-metal antifuse of Claim 20, wherein said layer of amorphous carbon is doped with at least one of hydrogen, fluorine, and hydrogen and fluorine.

22. The metal-to-metal antifuse of Claim 20, wherein said antifuse layer is about 10 nm to about 80 nm in thickness.

23. The metal-to-metal antifuse of Claim 20, wherein said first layer of said barrier metal layer and said second layer of said barrier metal layer are about 25 nm to about 200 nm in thickness.

24. The metal-to-metal antifuse of Claim 20, wherein said lower adhesion-promoting layer comprises amorphous silicon carbide, said middle layer comprises amorphous carbon, and said lower adhesion-promoting layer comprises amorphous silicon carbide.

25. The metal-to-metal antifuse of Claim 20, wherein said lower adhesion-promoting layer comprises amorphous silicon nitride, said middle layer comprises amorphous carbon, and said lower adhesion-promoting layer comprises amorphous silicon nitride.

26. A method for programming an antifuse comprising:

applying a first programming pulse of about 0.25 mA to about 0.5 mA to a first electrode of the antifuse, said antifuse comprising:

a tungsten plug disposed in a via in an insulating layer disposed above and in electrical contact with a lower metal interconnect layer forming a first electrode;

an antifuse layer disposed above an upper surface of said tungsten plug, said antifuse layer comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer; and

a layer of a barrier metal disposed over said antifuse layer forming a second electrode, said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride; and

applying a second programming pulse of about 0.25 mA to about 0.5 mA to said second electrode of the antifuse.

27. The method of Claim 26, wherein said first programming pulse and said second programming pulse are each applied for about 10 μs.

28. The method of Claim 26, further comprising:

applying a first soaking pulse of about 2 mA to about 5 mA to said first electrode; and

applying a second soaking pulse of about 2 mA to about 5 mA to said second electrode; and

repeating applying said first soaking pulse and applying said second soaking pulse.

29. The method of Claim 28, wherein said first programming pulse and said second programming pulse are applied for about 10 μs, and said first soaking pulse and said second soaking pulse are applied for about 1 ms.

30. The method of Claim 26, wherein said applying said first programming pulse and said applying said second programming pulse are repeated at least four more times.

31. The method of Claim 30, wherein said first programming pulse and said second programming pulse are applied for about 1 ms.

32. The method of Claim 30, further comprising:

applying a first soaking pulse of about 2 mA to about 5 mA to said first electrode;

applying a second soaking pulse of about 2 mA to about 5 mA to said second electrode; and

repeating said applying said first soaking pulse and said applying said second soaking pulse.

33. The method of Claim 32, wherein said first programming pulse and said second programming pulse are applied for about 1 ms, and said first soaking pulse and said second soaking pulse are applied for about 1 ms.

34. A method for programming an antifuse comprising:

applying a first programming pulse of about 0.25 mA to about 0.5 mA to a first electrode of the antifuse, said antifuse comprising:

a tungsten plug disposed in a via in an insulating layer disposed above and in electrical contact with a lower metal interconnect layer;

a first layer of a barrier metal disposed above and in electrical contact with said tungsten plug forming a first electrode, said first layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

an antifuse layer disposed above an upper surface of said tungsten plug, said antifuse layer comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer;

a second layer of a barrier metal disposed over said antifuse layer forming a second electrode, said second layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride; and

a second insulating layer disposed over said first insulating layer, said antifuse layer, said first layer of said barrier metal, and said second layer of said barrier metal; and

applying a second programming pulse of about 0.25 mA to about 0.5 mA to said second electrode of the antifuse.

35. The method of Claim 34, wherein said first programming pulse and said second programming pulse are each applied for about 10 μs.

36. The method of Claim 34, further comprising:

applying a first soaking pulse of about 2 mA to about 5 mA to said first electrode;

applying a second soaking pulse of about 2 mA to about 5 mA to said second electrode; and

repeating applying said first soaking pulse and applying said second soaking pulse.

37. The method of Claim 36, wherein said first programming pulse and said second programming pulse are applied for about 10 μs, and said first soaking pulse and said second soaking pulse are applied for about 1 ms.

38. The method of Claim 34, wherein said applying said first programming pulse and said applying said second programming pulse are repeated at least four more times.

39. The method of Claim 38, wherein said first programming pulse and said second programming pulse are applied for about 1 ms.

40. The method of Claim 38, further comprising:

applying a first soaking pulse of about 2 mA to about 5 mA to said first electrode;

applying a second soaking pulse of about 2 mA to about 5 mA to said second electrode; and

repeating said applying said first soaking pulse and said applying said second soaking pulse.

41. The method of Claim 40, wherein said first programming pulse and said second programming pulse are applied for about 1 ms, and said first soaking pulse and said second soaking pulse are applied for about 1 ms.

42. A method for programming an antifuse comprising:

applying a first programming pulse of about 0.25 mA to about 0.5 mA to a first electrode of the antifuse, said antifuse comprising:

a first layer of a barrier metal disposed on a surface forming a first electrode, said first layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

an antifuse layer disposed on said first layer of said barrier metal comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer; and

a second layer of a barrier metal disposed over said antifuse layer forming a second electrode, said second layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride; and

applying a second programming pulse of about 0.25 mA to about 0.5 mA to said second electrode of the antifuse.

43. The method of Claim 42, wherein said first programming pulse and said second programming pulse are each applied for about 10 μs.

44. The method of Claim 42, further comprising:

applying a first soaking pulse of about 2 mA to about 5 mA to said first electrode;

applying a second soaking pulse of about 2 mA to about 5 mA to said second electrode; and

repeating applying said first soaking pulse and applying said second soaking pulse.

45. The method of Claim 44, wherein said first programming pulse and said second programming pulse are applied for about 10 μs, and said first soaking pulse and said second soaking pulse are applied for about 1 ms.

46. The method of Claim 42, wherein said applying said first programming pulse and said applying said second programming pulse are repeated at least four more times.

47. The method of Claim 46, wherein said first programming pulse and said second programming pulse are applied for about 1 ms.

48. The method of Claim 46, further comprising:

applying a first soaking pulse of about 2 mA to about 5 mA to said first electrode;

applying a second soaking pulse of about 2 mA to about 5 mA to said second electrode; and

repeating said applying said first soaking pulse and said applying said second soaking pulse.

49. The method of Claim 48, wherein said first programming pulse and said second programming pulse are applied for about 1 ms, and said first soaking pulse and said second soaking pulse are applied for about 1 ms.

50. A method for programming an antifuse comprising:

applying a first low current programming pulse to a first electrode of the antifuse, said antifuse comprising:

a tungsten plug disposed in a via in an insulating layer disposed above and in electrical contact with a lower metal interconnect layer;

a first layer of a barrier metal disposed above and in electrical contact with said tungsten plug forming a first electrode, said first layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

an antifuse layer disposed above an upper surface of said tungsten plug, said antifuse layer comprising a lower adhesion-promoting

layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer;

a second layer of a barrier metal disposed over said antifuse layer forming a second electrode, said second layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride; and

a second insulating layer disposed over said first insulating layer, said antifuse layer, said first layer of said barrier metal, and said second layer of said barrier metal;

applying a second low current programming pulse to said second electrode;

applying a first high current soaking pulse to said first electrode; and

applying a second high current soaking pulse to said second electrode.

51. A method for programming an antifuse comprising:

applying a first low current programming pulse to a first electrode of the antifuse, said antifuse comprising:

a tungsten plug disposed in a via in an insulating layer disposed above and in electrical contact with a lower metal interconnect layer;

a first layer of a barrier metal disposed above and in electrical contact with said tungsten plug forming a first electrode, said first layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

an antifuse layer disposed above an upper surface of said tungsten plug, said antifuse layer comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer;

a second layer of a barrier metal disposed over said antifuse layer forming a second electrode, said second layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride; and

a second insulating layer disposed over said first insulating layer, said antifuse layer, said first layer of said barrier metal, and said second layer of said barrier metal;

applying a second low current programming pulse to said second electrode;

applying a first high current soaking pulse to said first electrode; and

applying a second high current soaking pulse to said second electrode.

52. A method for programming an antifuse comprising:

applying a first low current programming pulse to a first electrode of the antifuse, said antifuse comprising:

a first layer of a barrier metal disposed on a surface forming a first electrode, said first layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

an antifuse layer disposed on said first layer of said barrier metal comprising a lower adhesion-promoting layer, a middle layer comprising amorphous carbon, and an upper adhesion-promoting layer; and

a second layer of a barrier metal disposed over said antifuse layer forming a second electrode, said second layer of said barrier metal comprising a material selected from a group consisting of at least one of tantalum and tantalum nitride;

applying a second low current programming pulse to said second electrode;

applying a first high current soaking pulse to said first electrode; and

applying a second high current soaking pulse to said second electrode.